A global approach to assess the potential impact of climate change on stream water temperatures and related in-stream first-order decay rates

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Abstract:

Stream water temperature is an important factor used in water quality modeling. To estimate monthly stream temperature on a global scale, a simple nonlinear regression model was developed. It was applied to stream temperatures recorded over a 36-yr period (1965-2001) at 1659 globally distributed gauging stations. Representative monthly air temperatures were obtained from the nearest grid cell included in the new global meteorological forcing dataset-the Water and Global Change (WATCH) Forcing Data. The regression model reproduced monthly stream temperatures with an efficiency of fit of 0.87. In addition, the regression model was applied for different climate zones (polar, snow, warm temperate arid, and equatorial climates) based on the Koppen-Geiger climate classification. For snow, warm temperate, and arid climates the efficiency of fit was larger than 0.82 including more than 1504 stations (90% of all records used). Analyses of heat-storage effects (seasonal hysteresis) did not show noticeable differences between the warming/cooling and global regression curves, respectively. The maximum difference between both limbs of the hysteresis curves was 1.6 degrees C and thus neglected in the further analysis of the study. For validation purposes time series of stream temperatures for five individual river basins were computed applying the global regression equation. The accuracy of the global regression equation could be confirmed. About 77% of the predicted values differed by 3 C or less from measured stream temperatures. To examine the impact of climate change on stream water temperatures, gridded global monthly stream temperatures for the climate normal period (1961-90) were calculated as well as stream temperatures for the A2 and B1 climate change emission scenarios for the 2050s (2041-70). On average, there will be an increase of 1 degrees-4 degrees C in monthly stream temperature under the two climate scenarios. It was also found that in the months December, January, and February a noticeable warming predominantly occurs along the equatorial zone, while during the months June, July, and August large-scale or large increases can be observed in the northern and southern temperate zones. Consequently, projections of decay rates show a similar seasonal and spatial pattern as the corresponding stream temperatures. A regional increase up to similar to 25% could be observed. Thus, to ensure sufficient water quality for human purposes, but also for freshwater ecosystems, sustainable management strategies are required.

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Resource Description

Climate Scenario : ☒

specification of climate scenario (set of assumptions about future states related to climate)

Special Report on Emissions Scenarios (SRES)

Special Report on Emissions Scenarios (SRES) Scenario: SRES A2, SRES B1

Exposure :

weather or climate related pathway by which climate change affects health

Food/Water Quality

Food/Water Quality: Other Water Quality Issue

Water Quality (other): Stream water temperature

Geographic Feature:

resource focuses on specific type of geography

Freshwater

Geographic Location:

resource focuses on specific location

Global or Unspecified

Health Impact:

specification of health effect or disease related to climate change exposure

Health Outcome Unspecified

Mitigation/Adaptation:

mitigation or adaptation strategy is a focus of resource

Mitigation

Model/Methodology:

type of model used or methodology development is a focus of resource

Exposure Change Prediction

Resource Type:

format or standard characteristic of resource

Research Article

Timescale:

time period studied

Long-Term (>50 years)

Vulnerability/Impact Assessment:

resource focus on process of identifying, quantifying, and prioritizing vulnerabilities in a system

A focus of content